EXPRESS MAIL LABEL NO. EU199220245US

Attorney Docket No. BVW014

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION FOR UNITED STATES LETTERS PATENT

TITLE OF THE INVENTION:

Blow-molding Large, Relatively Thick-walled, Thermoplastic Resin Products.

CROSS-REFERENCES:

None.

FIELD OF THE INVENTION:

The present invention relates generally to the manufacture of large, relatively thick-walled, blow-molded, thermoplastic-resin products, and particularly concerns both methods and apparatus for accomplishing the separation of gutter flash that is first integrally attached to a large, relatively thick-walled, blow-molded product from the product entirely around the product mold-line perimeter while the product is fully restrained in the product-forming mold cavity of the invention apparatus.

BACKGROUND OF THE INVENTION:

It is common practice in the United States in connection with the manufacture of large, relatively thick-walled blow-molded thermoplastic resin products using conventional production blow-molding machines and known blow-mold assemblies to eject the molded product with simultaneously formed and completely surrounding gutter flash from the mold assembly, and to afterwards completely separate the integrally attached flash from the ejected blow-molded product by subsequent combined operations such as sequential cutting and grinding or sequential shearing and grinding. The operating forces and processing time required to so-separate and remove such flash, either manually or by machine, are, in the case of many blow-molded products, extremely large. The required flash separation forces and flash removal process times are especially substantial in cases where the blow-molding machine production cycle unit output is comprised of either a single blow-molded product or multiple blow-molded products with integrally attached gutter flash having a substantial total length of gutter flash trim edge.

In the teachings of U.S. Patent No. 5,480,607 granted to Hobson a method of separating integrally attached flash from a product during the molding process is disclosed, but such method utilizes a step wherein the flash is temporarily secured to the apparatus blow-mold and the formed product is separated from the restrained integral flash by applying product mold ejector pin forces to the blow-molded product with the mold assembly in a partially open condition. The ejection forces required may be undesirably large and also generally cause ejector pin damage to the formed product in high-rate production cycles wherein the blow-molded product has an elevated temperature and a substantial degree of residual parison plasticity at time of flash separation and product ejection from its mold.

I have discovered a novel method of progressively separating integrally-attached gutter flash from a blow-molded product, and also novel mold assembly constructions and methods of assembly operation, that may be used in conjunction with a conventional production blow-molding machine to achieve complete, or very nearly complete, separation of otherwise integrally attached surrounding gutter flash from blow-molded products while the products are fully restrained by the mold apparatus and prior to product ejection from within the mold apparatus. Subsequently the individual blow-molded thermoplastic resin products and separated gutter flash are ejected from the mold assemblies in which they were formed and removed from the co-operating conventional production blow-molding machine. Because very short blow-molding machine operating cycle unit times may be achieved with the novel in-mold product de-flashing, and because the apparatus takes advantage of separate product and gutter flash removal procedures, the blow-molded thermoplastic resin products and separate gutter flash have no possibility of being inadvertently fused together.

In addition, when it has been discovered that the wall thickness configuration characteristic of the produced blow-molded product in the region of the product mold parting-line perimeter is not that which is desired, e.g. is convex or of uniform wall thickness rather than concave, is concave or of uniform wall thickness rather than convex, etc., it has been necessary and costly to rather extensively re-work the blow-mold assembly to obtain correction to the desired product wall thickness configuration at the product mold parting line perimeter. I have found that the required rather extensive blow-mold assembly re-working is not necessary if using the improved blow-mold apparatus of the present invention.

Other objects and advantages of the present invention will become apparent during consideration of the detailed descriptions, drawings, and claims which follow.

SUMMARY OF THE INVENTION:

I have invented a blow-mold assembly that is intended for use with a conventional production blow-molding machine and that is comprised of co-operating and separable cap and base blow-mold sub-assemblies, the base blow-mold sub-assembly having multiple elongated gutter plate segments which together surround the blow-mold assembly product mold cavity when abutted, which each may be moved linearly in directions toward or away from the cap blow-mold sub-assembly to obtain different product wall thickness and internal surface configuration characteristics at the product mold parting-line perimeter, and which also are pivoted or rotated in directions transverse to the direction of linear gutter plate segment movement to progressively separate gutter flash from around the blow-molded product while the product is retained in the apparatus product mold cavity. Further, the blow-mold assembly invention, with modification, is useful for additionally separating from the product a gutter flash core integrally attached to the product at a product interior mold parting-line perimeter also while the product is retained in the apparatus product mold cavity.

Several different blow-mold assembly embodiments and methods of blow-molding a product for implementing the invention are disclosed and described in detail.

BRIEF DESCRIPTION OF THE DRAWINGS:

Figure 1 is a schematic perspective view of a conventional production blow-molding machine within which the methods and apparatus of the present invention may be practiced;

Figure 2 is a schematic elevation view of the interior of the blow-molding machine of Figure 1 illustrating a preferred embodiment the base and cap blow-mold sub-assemblies of the present invention in an operationally separated condition;

Figure 3 is similar to Figure 2 except that the included invention cap and base blow-mold sub-assemblies are illustrated in an operationally closed condition;

Figure 4 is similar to Figure 3 except that it is a plan view of a the interior of the blow-molding machine of Figure 1 illustrating the blow-mold sub-assemblies of the present invention in a fully closed condition;

Figure 5 is an orthogonal view of the invention base blow-mold sub-assembly shown in Figures 2 through 4 in an initial operating condition;

Figure 6 is an orthogonal view of the invention base blow-mold sub-assembly similar to Figure 3 but in a subsequent operating condition;

Figure 7 is a section view taken at line 7-7 of Figure 3 in an invention blow-mold assembly initial operating condition;

Figure 8 is a view similar to Figure 7 but in an invention blow-mold assembly subsequent operating condition;

Figure 9 is an enlarged view of the portion of Figure 7 circled with a dotted line;

Figure 10 is an enlarged view of the portion of Figure 8 circled with a dotted line;

Figure 11 is a section view taken at line 11-11 of Figure 13;

Figure 12 is a schematic plan view of the product that is blow-molded in the apparatus of Figures 1 through 11 and its fully-separated gutter flash;

Figure 13 is a schematic front elevation view of the invention Figure 5 base blow-mold sub-assembly but with the gutter plate segments surrounding the mold cavity having an alternate configuration;

Figure 14 is a schematic diagram of one form of control system that may be utilized to obtain proper sequencing of the several bi-directional actuator devices incorporated in the apparatus of Figures 1 through 11;

Figures 15 through 17 are section views similar to Figure 9 but illustrating the different product parting line perimeter wall thickness or wall internal surface characteristics that can be obtained by practice of the present invention;

Figure 18 is an orthogonal view of another embodiment of the invention base blow-mold sub-assembly shown in an initial operating condition;

Figure 19 is an orthogonal view of the invention base blow-mold sub-assembly of Figure 18 in a subsequent operating condition;

Figure 20 is a schematic section view taken at line 20-20 of Figure 18;

Figure 21 is a schematic section view taken at line 21-21 of Figure 18 to illustrate included gutter flash ejector pin elements in a retracted operating condition;

Figure 22 is similar to Figure 21 but illustrating the included gutter flash ejector pin elements in a subsequent extended operating condition;

Figure 23 is an elevation view illustrating the molded part and gutter flash components that are ejected from the blow-molding machine of Figures 1 through 4 when utilizing the base blow-mold sub-assembly of Figures 18 and 19;

Figure 24 is an schematic orthogonal view of still another embodiment of the invention base blow-mold sub-assembly in an initial operating condition;

Figure 25 is a schematic section view taken at line 25-25 of Figure 24 to illustrate included invention internal crash pad elements in an extended operating condition;

Figure 26 is similar to Figure 25 but illustrating the included crash pad elements in a retracted operating condition;

Figure 27 is a schematic section view taken at line 27-27 of Figure 24 to illustrate included gutter plate segment support pin elements in a first operating condition;

Figure 28 is similar to Figure 27 but illustrating the included gutter plate support pin elements in a different operating condition;

Figures 29 and 30 schematically and orthogonally respectively illustrate additional cap blow-mold sub-assembly and base blow-mold sub-assembly constructions that may be utilized in another application for the invention apparatus using the blow-molding machine of Figures 1 through 4;

Figure 31 is a section view illustrating the blow-mold sub-assemblies of Figures 29 and 30 in an assembled and first operating condition;

Figure 32 is a section view similar to Figure 31 but illustrating the sub-assemblies in a second operating condition;

Figure 33 is an enlarged view of the portion of Figure 32 circled with a dotted line;

Figure 34 is a schematic orthogonal view of yet another embodiment of the base blow-mold sub-assembly of the present invention;

Figure 35 is a section view through the invention blow-mold assembly taken, with blow-molded product in place, at line 35-35 of Figure 34;

Figure 36 is a plan view of the product mold half included in the base blow-mold sub-assembly of Figure 34;

Figure 37 is a section view taken at line 37-37 of Figure 34;

Figure 38 is a schematic front elevation view of another embodiment of the base blow-mold sub-assembly of the present invention with the included elongate and double-pivoted gutter plate segments in an initial operating condition;

Figure 39 is a view similar to Figure 38 but illustrating the included elongate and double-pivoted gutter plate segments in a subsequent operating condition;

Figure 40 is a back elevation view schematically illustrating a first embodiment of the of the Figures 38 and 39 base blow-mold sub-assembly gutter plate segment drive;

Figure 41 is similar to Figure 40 but schematically illustrating a second or different embodiment of the Figures 38 and 39 base blow-mold sub-assembly gutter plate segment drive;

Figure 42 is a partial break-away orthogonal view of the base blow-mold sub-assembly corner area construction utilized in invention embodiments of Figures 38 through 41;

Figure 43 is a schematic front elevation view of a base blow-mold sub-assembly construction for use in effecting progressive separation of an integrally attached gutter flash interior core from a blow-molded product, and illustrated in an initial operating condition;

Figure 44 is similar to Figure 43 but illustrating the blow-mold sub-assembly in a subsequent operating condition;

Figure 45 is a back elevation view schematically illustrating a first embodiment of the of the Figures 43 and 44 base blow-mold sub-assembly gutter plate segment drive;

Figure 46 is a section view taken at line 46-46 of Figure 43; and

Figure 47 is a section view taken at line 47-47 of Figure 44.

DETAILED DESCRIPTION:

The method of the present invention involves a basic step sequence of blow-molding an extruded and heated thermoplastic resin parison contained within co-operating and operationally closed blow-mold sub-assemblies to form a large, relatively thick-walled, hollow product with a gutter flash integrally attached to the product entirely around the product mold parting-line perimeter, separating the integrally attached gutter flash from the blow-molded product progressively along each product mold parting-line perimeter side, and afterwards separating the closed blow-mold sub-assemblies for purposes of accomplishing removal of the product and separated gutter flash from the blow-mold apparatus. The forces applied to the gutter flash during such progressive gutter flash separation are essentially tension forces rather than conventional cutting or shear forces.

Figures 1 through 3 schematically illustrate a conventional industrial blow molding machine **10**, such as the large-size either SE or SL Series "Sterling" blow molding system manufactured and marketed by Davis-Standard Corporation of Edison New, Jersey, customized to include the blow-mold assemblies utilized in the practice of the present invention.. Such machine generally has a throat size that often ranges to approximately 84 inches by 60 inches, and is especially well adapted to the production in each machine cycle of a single very large blow-molded product utilizing an extremely short production cycle time generally varying from approximately 45 to 60 seconds per cycle. The production rates for machine **10** typically are in the range from 60 to 80 or more units per hour of a large, relatively thick-walled, blow-molded product. Such machine is capable of blow-molding a variety of different thermoplastic resins including polyolefin resins and other resins such as polycarbonate, polyethylene, polyvinylchloride, and like resins that are technically-formulated for use in blow-molding applications.

Machine **10** typically includes the illustrated feedstock hopper **12**, a feed screw feedstock conveyor **14**, and a conventional melter-accumulator-extruder sub-assembly **16** with variably-controlled parison die head **18**. Machine **10** also includes guideposts **19** upon which movable platens **20** and **24** reciprocate. Movable machine platen **20** carries base blow-mold sub-assembly **22** and movable machine platen **24** carries cap blow-mold sub-assembly **26**. Although such base and cap blow-mold sub-assemblies have co-operating complementary product-forming cavities and generally similar constructions, their respective total function differs.

Machine platen **20** is powered by bi-directional rapid traverse hydraulic actuator **28** and additionally by bi-directional clamping hydraulic actuators **32** and **34**; machine platen **24** is powered by bi-directional rapid traverse hydraulic actuator **30** and additionally by bi-directional clamping hydraulic actuators **36** and **38**. In addition, conventional blow-molding machine **10** typically includes trimmed blow-mold product discharge conveyor **42**, flash discharge conveyor **44**, and may optionally also include a conventional overhead discharge conveyor **46** (see Figure 1) normally utilized for removing conventionally formed product units with integrally attached flash from within the machine. Machine **10** typically also includes a operator's control panel or control station **48** and access doors **50** which, when opened, provide access to the interiorly-located invention blow-mold sub-assemblies **22** and **26** for installation and maintenance servicing purposes and the like.

As shown in Figures 4 and 5, base mold sub-assembly **22** is provided with a base plate **60** to which are rigidly attached slotted platen mounting blocks **62** and **64**, intermediate support block **66**, and external crash pads **68** and **70** which function to maintain a proper base blow-mold sub-assembly distance of separation from cap blow-mold sub-assembly **26** when such blow-mold sub-assemblies are positioned in an operationally closed condition with respect to each other, usually a small distance

generally not exceeding approximately ten thousandths (0.010) of an inch and often to as little as approximately one thousandth (0.001) of an inch, the separation in that range utilized in a particular apparatus blow-mold assembly being controlled in some instances by the selection and installation of multiple sets of different hereinafter-described shim combinations. Also, this separation distance may increase somewhat both when pressurized air is being injected into the interior of the parison segment constrained by the mold sub-assemblies during product formation, and also after the actuators forcing the mold sub-assemblies together are relieved of internal fluid pressures prior to opening the mold sub-assemblies for product and gutter flash removal purposes. Crash pads **70** each have a projecting tapered guide pin **72** that co-operates with a complementary crash pad tapered guide pin receptacle **74** provided in a crash pad element **68**.

Base blow-mold sub-assembly **22** also includes product mold half **80** that is rigidly mounted on base plate **60**, and that has a product cavity half **82**, pneumatically-actuated conventional bi-directional product ejectors **84**, and a pneumatically-actuated extendible and retractable inflation needle **86** that injects pressurized air into the interior of parison **40** to effect parison expansion. Elongate gutter plate segments **90, 92**, **94**, and **96**, together surround cavity **82** of product mold half **80** at the cavity mold parting-line perimeter when their ends each abut the ends of an adjacent gutter plate segment . The essentially flat surface of each such gutter plate segment that opposes and is nearest cap blow-mold sub-assembly **26** is a gutter flash clamping surface designated in the drawings with the reference numeral 87, and includes an excess gutter flash receiver **98** which in Figures 5 through 13 takes the form of multiple, excess gutter flash, tapered blind-hole recesses. As discussed in connection with Figures 15 through 17, each such receiver element **98** is provided for the purpose of accommodating excess heated parison material associated with the particular distance that

separates the gutter flash clamping surface **83** of cap blow-mold sub-assembly **26** from the gutter flash clamping surfaces **87** of the sub-assembly **22** pivoted gutter plate segments. Also, each such gutter plate segment included in mold sub-assembly **22** preferably includes multiple, conventional, bi-directionally and pneumatically-actuated gutter flash ejectors **100**, a longitudinal coolant passageway **102**, and an upstanding integral gutter flash separation blade element **97** positioned transversely at one or at each extreme end region of each elongated gutter plate segment. See Figure 11. Blade element **97** substantially cuts through said gutter flash to enable said gutter plate segments **90**, **92**, **94**, and **96** to pivot and progressively tear said gutter flash.

Cap blow-mold sub-assembly **26**, although constructed to be generally similar to base blow-mold sub-assembly **22** with respect to its basic components, has a somewhat different total function than does its co-operating base blow-mold sub-assembly **22**. The cap blow-mold sub-assembly's mold half, which is designated **81** in Figures 5 through 10 and which together with co-operating product mold half **80** comprises the apparatus product mold with an interior product-forming cavity **82**, has an integral gutter with gutter flash clamping surface **83** which completely surrounds the product cavity periphery areas situated opposite the gutter flash clamping surfaces **87** of gutter plate segments **90** through **96**. Such cap blow-mold sub-assembly flat gutter flash clamping surface **83** also preferably diverges away from the gutter flash clamping surfaces **87** of the gutter plate segments of base blow-mold sub-assembly **22** outwardly from the product cavity mold parting-line perimeter **108**. The resulting "taper" is preferably at least about a 1° angular departure, sometimes is imparted to a flat continuous gutter flash clamping surface **83**, but optionally and often preferably, may advantageously includes an intermediate step or offset **85** located outwardly of mold parting-line perimeter **108** - usually about 3/4 inch from the parting-line perimeter, and just outwardly of the

position of concave excess gutter flash receiver or cleat **98** or its elements provided in the different invention gutter plate segment configurations. See Figure 10. Also, since blow-mold sub-assembly **26** does not support any of the invention pivoted and abutting gutter plate segments it is not provided with bi-directional hydraulic actuators for effecting pivotal movement of the invention gutter plate segments. While it is important that each gutter plate segment of sub-assembly **22** is provided with a longitudinal cooling water passageway **102** that is connected to a flowing source of liquid coolant such as cooling water, it is also important that product mold halves **80** and **81** of blow-mold subassemblies **22** and **26** each be provided with interconnected cooling water passageways **106** that are situated in the region of the product mold parting-line perimeter **108** and that are connected to a source of flowing coolant. In some applications the coolant may have a solidification temperature significantly lower than the solidification temperature of water, i.e. significantly lower than 32° Fahrenheit. See Figures 7 through 10 for illustration of the location of coolant passageways in proximity to the mold parting-aline perimeter **108**.

It should be noted that each end-abutting and double-pivoted gutter plate segment **90**, **92**, **94** and **96** utilized in the practice of my invention is provided with two pivot axes, each such pivot axis having a longitudinal axis that is transverse (at right angles) to the plane of the product cavity mold parting-line perimeter and that is positioned at or in a different one of the end regions or opposite extremes of the elongated gutter plate segment. In some invention embodiments both pivot axes are movable in directions lying in the plane of the product cavity mold parting-line perimeter. In other invention embodiments, only one such pivot axis of a gutter plate segment is movable relative to the product cavity mold parting-line perimeter, while the other such pivot axis is maintained in a relatively fixed position. The movable pivot axes are moved (powered) by a co-operating bi-directional

actuator, and extension and retraction of the actuator piston rod causes the connected gutter plate segment to be rotated about or relative to each of its pivot axes.

Base blow-mold sub-assembly **22** includes a gutter plate segment drive which in the Figures 5 and 6 embodiment is comprised of bi-directional hydraulic actuators **110** through **124** that are each rigidly mounted on structure of sub-assembly **22** and, as shown in detail, the piston rod free end of each such actuator is connected to its respective end region of the adjacent gutter plate segment **90**, **92**, **94** and **96** by a pivot connection **126** that includes its respective putter plate segment pivot axis. Each such pivot connection preferably is designed to permit the attached gutter plate segment to: (1) primarily be rotated about the pivot axis of the pivot connection for purposes of effecting progressive gutter flash separation from the blow-molded product while the product is fully retained within the assembly product cavity, and (2) secondarily be translated in directions parallel to the pivot axis of the pivot connection for purposes of establishing the desired product wall thickness configuration at the product mold parting line perimeter **108**. See Figures 7 through 10 and the discussion of Figures 15 through 17. A different number of thin shims **128** may be inserted under each bronze wear bushing **130** that supports a gutter plate segment underside bronze wear surface **132**, or alternatively, the bronze wear bushings may be extended or retracted using the actuating mechanism discussed in connection with the apparatus particulars of Figures 27 and 28. Pivot connections **126** enable the pair of bi-directional hydraulic actuators connected to the opposite or extreme ends of an invention elongated gutter plate segment **90**, **92**, **94** and **96** having two movable pivot axis to be actuated differentially to effect the progressive separation of integrally attached gutter flash from product **P** along the product mold parting-line perimeter **108**.adjacent the gutter plate segment.

Also, and while not shown in the drawings or suggested elsewhere, other primary power sources such as electric motors combined with various mechanical linkages, devices, and the like may be substituted for bi-directional actuator components **110** through **124** and utilized as the actuators that cause movement of gutter plate segments **90** through **96** relative to the co-operating product molds.

In Figure 13 I illustrate, in elevation, the gutter plate segment gutter flash clamping surfaces of invention blow-mold assembly **22** as having a different arrangement of tapered, blind- hole recesses that comprise excess gutter flash receiver elements **98** in comparison to the arrangement of Figures 5 and 6. Since the descending and superimposed heated tubular parison **40** illustrated in Figure 13 has programmed sections or zones of reduced thickness **40a** and of increased thickness **40b** to meet product wall thickness needs, I find it preferable to have added excess gutter flash receiver element **98** capacity in the adjacently situated zones of the gutter plate segments **90**, **92**, **94**, and **96** that surround the product cavity of apparatus product mold half **80** rather than increased receiver element depth. Basically, I strive to have an extent of receiver element surface area or volume provided in the gutter plate segments that generally is directly proportional to the volume (i.e., wall thickness) of thermoplastic resin material in the adjacent zones or sections of the descended heated parison. Figure 14 schematically illustrates one type of control system that may be utilized in connection with combined blow-mold sub-assemblies **22** and **26** to obtain proper sequencing of the different incorporated pneumatic/hydraulic bi-directional actuators in order to carry out the basic product de-flashing steps of my method invention for the product application of Figures 1 through 13. Such control system preferably includes a compressed air source **150**, a pressurized hydraulic fluid supply **152** with fluid reservoir **154**, and a conventional programmable valve position sequence

controller **156** that sequentially activates each of the included conventional 4-way fluid valves **158** to its different valve operating positions and thereby achieve full extension or full retraction of each of the specifically numbered bi-directional actuators connected thereto at the proper time in each production cycle of blow-molding machine **10**.

The basic sequence of steps for operating blow-molding machine or system **10**, including blow-mold sub-assemblies **22** and **26**, for a complete machine production cycle are as follows:

1. Activate machine **10**.
2. Retract platens **20** and **24** to fully-separate (open) blow-mold sub-assemblies **22** and **26** (machine function).
3. Cause heated tubular thermoplastic resin parison **40** to descend from die-head **18** to lower edges of assemblies **22** and **26** (machine function).
4. Rapid advance platens **20** and **24** sufficient to engage all crash pads **68** and **70** and thereby fully close blow-mold sub-assemblies **22** and **26** by actuating rapid traverse hydraulic actuators **28** and **30** (machine function).
5. Clamp blow-mold sub-assemblies **22** and **26** together by simultaneously activating hydraulic actuators **32**, **34**, **36**, and **38** (machine function) to engage and contact fully gutter plate segments **90** through **96** with the gutter flash **F**, and to flow excess thermoplastic resin parison material into surface reservoirs **98**, whereupon accelerated cooling of parison gutter flash material commences.
6. Insert inflation needles **86** into the descended parison contained within mold assemblies **22** and **26**.
7. Inject compressed air into contained parison thereby expanding heated parison

thermoplastic resin into complete contact with the product cavities **82** of blow-mold sub-assemblies **22** and **26** (machine function) and form thermoplastic resin product **P**.

8. . Activate (retract) bi-directional hydraulic actuators **110**, **114**, **118**, and **122** to pivot gutter plate segments **90**, **92**, **94**, and **96**, respectively, thereby separating gutter flash **F** from blow-molded product **P** progressively along the product mold parting line perimeter using tension forces.
9. Complete gutter flash separation by activating (retracting) bi-directional hydraulic actuators **112** , **116**, **120**, and **124** to additionally pivot ("rock") gutter plate segments **90**, **92**, **94**, and **96**, respectively, but in an opposite rotational sense to thereby complete separation of gutter flash **F** from blow-molded product **P** progressively along the product mold parting-line perimeter using tension forces.
10. Reverse the actuation of clamping bi-directional hydraulic actuators **32**, **34**, **36**, and **38** (machine function) to release mold assembly clamping pressures.
11. Reverse the actuation direction of bi-directional rapid traverse hydraulic actuator **30** to partially separate and open blow-mold assemblies **22** and **26**.
12. Actuate pneumatic bi-directional gutter flash ejectors **100** to separate gutter flash segments **F** from engagement with the gutter plate segments **90**, **92**, **94**, and **96** of blow-mold sub-assembly **22** for free-fall to the machine flash removal conveyor **44**.
13. Reverse the actuation direction of bi-directional rapid traverse hydraulic actuator

28 to fully separate and open blow-mold sub-assemblies **22** and **26**.

14. Actuate product ejectors **84** to release product units **P** from product mold cavities **82** for free-fall to the machine product removal conveyor **42**.
15. Extend bi-directional hydraulic actuators **110** through **124** to return gutter plate segments **90, 92, 94**, and **96** to their initial position abutting assembly mold **80**.
16. Repeat steps 3 through 15 to end of machine production run.

Other arrangements for sequencing the actuation of gutter plate segments **90** through **96** for the separation of gutter flash from product **P** may be utilized. For instance, bi-directional hydraulic actuators **112, 114, 120**, and **122** may be ganged and retracted simultaneously, followed by the retraction of ganged actuators **116, 118, 124**, and **110** simultaneously. Also, it is permissible to actuate the different pairs of corner actuators, e.g. **112, 114** and **120, 122** or **116, 118** and **124, 110** either simultaneously or serially. In any event, I prefer to not simultaneously retract both actuators connected to any one of the system gutter plate segments, i.e. I do not retract actuator pairs such as **110/112, 114/116, 118/120**, or **122/124** simultaneously.

Figures 15, 16, and 17 illustrate three different product wall thickness or interior surface configuration conditions that may be obtained in the region of the product mold cavity parting line perimeter using the apparatus of Figures 1 through 13. Such are achieved using different combinations of the thickness of shim elements **128** placed beneath bronze wear bushings **130** and the different total extent of excess gutter flash receiver elements **98** surface opening area. See Figures 9 and 10. As mentioned above, pivot connections **126** enable gutter plate segments **90, 92, 94** and **96** to move in directions parallel to their pivot axes to change their distances from gutter flash

clamping surface **83** of cap blow-mold sub-assembly **26**. The product uniform wall thickness condition or configuration of Figure 15 is nominally uniform and normally preferred, and the required thickness of shim elements **128** is arrived at during initial set-up trial runs of the invention apparatus rather than by arithmetic calculation. If the localized and thickened wall condition shown in Figure 16 is desired, thereby having an essentially convex interior surface configuration, additional thickness of shim elements **128** may be provided or the area extent of adjacent openings of excess gutter flash receiver elements **98** may be reduced. Figure 17 illustrates a thinned product wall thickness condition (concave interior surface configuration) at the product mold-cavity parting line perimeter. Such occurs due to either reduced shim thickness under bronze wear bushing elements **130** or an increased adjacent excess gutter flash accumulator element surface area opening capacity. The thinner product wall thickness is often desired in instances where the product is to have an integrally molded and expandable bellows feature, for instance.

In some blow-molding applications it is desired, because of large product sizes being involved, to remove formed products with partially-attached gutter flash from blow-molding machine **10** as units using overhead take-out conveyor **46** (Figure 1) rather than product conveyor **42** (Figures 2 through 4). In such product applications I utilize the base blow-mold sub-assembly **222** of Figures 18 through 22 in preference to the base blow-mold sub-assembly **22** shown in Figures 5 and 6. The important differences between such sub-assemblies relate to the use of elongated gutter plate segments **290**, **294**, and **296** that each have a relatively-fixed pivot axis **224** positioned near or located at one end, and one bi-directional hydraulic actuator, **110**, **120**, or **122**, pivotally attached to a movable pivot axis at the opposite end. Such an arrangement is sometimes preferred over an arrangement wherein each gutter plate segment has two movable pivot axes with pivotally attached

bi-directional hydraulic actuator components as shown in Figures 5 and 6. Details of fixed pivot **224** and its installation in bronze sleeve bushing **226** in support structure for product mold half **280** are provided in Figure 20. Note that the position of each gutter plate segment **290**, **294,** and **296** may be translated in directions normal to the plane of the product mold parting line perimeter by longitudinal sliding movement of fixed pivot **224** within and relative to bronze sleeve bushing **226**. This allows the thickness of the gutter flash to be adjusted to thereby set a desired wall thickness characteristic at the product mold cavity parting-line perimeter as discussed above.

The apparatus of Figures 18 and 19 also differs from that of Figures 5 and 6 in the use of a different arrangement for actuating gutter flash ejectors . More particularly, and as shown in Figure 21 and 22, rather than having an individual bi-directional pneumatic actuator within the gutter plate segment for each gutter flash ejector as in the Figure 5 and 6 scheme, gutter plate segments **290** and **294** each have an internally-located elongated, multi-ramp slide member **226** that is connected to and powered by bi-directional pneumatic actuator **228** mounted on the gutter plate segment and that co-operates with each individual ejector pin **200**. (The respective bi-directional actuators for extending and retracting such ejector pins may be mounted on the undersides of the sub-assembly gutter plate segments and received in adjacent recesses in product mold half **280** in the manner disclosed in connection with the crash pad guide pins of the base blow-mold sub-assembly embodiment of Figures 34 through 37). Each ejector pin **200** is spring biased to a retracted position by a spring **201** and has one end which engages a ramp **227** in multi-ramp slide member **226** which causes said ejector pin **200** to move between a retracted position shown in Figure 21 and an extended position depicted in Figure 22 when bi-directional pneumatic actuator **228** causes slide member **226** to move between its two extreme positions.

As illustrated in Figure 23, the molded product **P** that is produced using sub-assembly **222** retains gutter flash **F** in an attached condition along a very short segment of the product mold parting-line perimeter located adjacent the apparatus uppermost pivots **224**. Such enables the product conveyor **46** (Figure 1) to grasp the product and gutter flash combination during each production cycle for discharge through access doors **50**, such doors being in an fully-opened condition.

Figures 24 through 28 disclose details of a still different embodiment of the blow-molding apparatus of the present invention - an embodiment that is particularly useful in instances wherein blow-molding machine equipment configuration limitations and product size characteristics preclude the installation and use of a base blow-mold sub-assembly having components such as bi-directional hydraulic actuators projecting outwardly from either side of the sub-assembly. The alternate embodiment is designated **322** in the drawings, and basically is comprised of two end-abutting and pivoted gutter plate segments **390** and **394**, a bi-directional dual hydraulic gutter plate segment actuator **350**, and interiorly-situated internal cylindrical crash pad elements **370** which are reciprocally powered by bi-directional actuators **374**. It should be noted that in this embodiment the crash pads **370** project through the gutter plate segments **390** and **394** but may be retracted so as to not subsequently interfere with the pivoting of those gutter plate segments by operation of dual bi-directional actuator **350**. These latter actuator elements may be either conventional hydraulic or pneumatic bi-directional actuators and each is connected to a respective, internally-located and elongated, multi-ramp slide member **326** that co-operates with and reciprocally powers their respective reciprocating crash pad elements **370**. To assure complete retraction of the crash pad elements from within their respective gutter plate segment upon withdrawal reciprocation of multi-ramp slide member **326** each crash pad element and **370** is surrounded by a compressed return

compression spring **378**. Each multi-ramp slide member **326** is connected to a bi-directional actuator **374** for reciprocal movement between a crash pad element **370** extended position depicted in Figure 25 and a crash pad element **370** retracted position depicted in Figure 26.

Referring to Figures 27 and 28, base blow-mold sub-assembly **322** also includes sets of extensible and retractable bronze wear bushing elements **330** that reciprocate within product mold half **380**. Such bushing sets co-operate with and are powered by a respective, internally-located and elongated, multi-ramp slide member **334** which in turn is operationally connected to and powered by a respective bi-directional actuator **376** illustrated only in Figures 24, 27, and 28. As in the case of crash pad elements **370**, each bronze wear bushing element **330** also is provided with a surrounding return compression spring **378**. Bronze wear bushing elements **330** when extended set the distance between gutter plate segments **390** and **394** and the gutter flash clamping surface of cap blow-mold sub-assembly mold half **381**.

It is important to note that excess gutter flash receiver elements **398** which are included in sub-assembly **322** each have an elongated and tapered blind-slot configuration, and together essentially surround, and are uniformly spaced apart from, the peripheral edges or perimeter of product-defining mold cavity **382**. Because the configuration of the product **P** to be molded using sub-assembly **322** has a central bellows section which requires a comparatively thin product wall thickness, the adjacent excess gutter flash receiver elements **398** each include a centrally situated section **398a** that has a substantially increased width and that provides additional adjacent excess gutter flash receiver capacity. See the above discussion of Figure 17.

In Figures 29 through 33 I illustrate a blow-mold assembly that may be utilized in the blow-molding machine **10** of Figures 1 through 4 and that is comprised of base blow-mold sub-assembly

422 depicted in Figure 30 and cap blow-mold sub-assembly **426** illustrated in Figure 29. However, rather then be utilized to produce a hollow large, relatively thick-walled thermoplastic resin product, such blow-mold assembly is utilized to form a laminated and contoured product. Such product, also designated as **P** in Figure 33, is formed from a sheet-like heated parison **440** of thermoplastic resin material and a sheet-like pliable (i.e., compliant) and stretchable mat **442** of densely randomly-oriented and partially-fused thermoplastic resin fibers. (See Figure 31 and 32). The latter material is frequently utilized as a fabric-like surface covering such as in various automotive part applications, e.g. automobile luggage compartment linings, automobile luggage compartment wheel covers, etc.

Cap blow-mold sub-assembly **426** is provided with pivoted and abutting cap gutter plate segments **490a** and **494a** that each include multiple projecting cleat elements **493** and that each mesh in a unifying sense respectively with gutter plate segments **490b** and **494b** of base blow-mold sub-assembly **422**. Meshing and proper blow-mold sub-assembly alignment upon mold closure is assured by the co-operation of gutter plate segment tapered guide pins **472** with tapered guide pin receptacles **474**. Convex projecting cleat elements **493** engage and penetrate into thermoplastic resin mat **442** to retain its edges in a clamped condition during the forming and laminating of product **P** in the mold assembly fully-closed operating condition.

In the utilization of the blow-mold assembly comprised of sub-assemblies **422** and **426** to produce the laminated product **P** of Figures 32 and 33, compressed air is introduced into the mold cavity **82** from injection needle **86** only after the after the cap and base blow-mold sub-assemblies **426** and **422** have been operationally closed with parison and matting sheets **440** and **442** clamped between co-operating gutter plate segment **490a**, **494a**, **490b**, and **494b**. The injected compressed

air then causes the sheets of material to conform to the configuration of the product cavity in blow-mold half **481** and to become fused together as a rigid lamination.

In Figures 34 through 37 I illustrate certain details of an embodiment **522** of the invention base blow-mold sub-assembly that, although differing from previously disclosed base blow-mold sub-assembly embodiments, may also be advantageously utilized in the production of large, relatively thick-walled blow-molded thermoplastic resin products. The principal differences of this particular base blow-mold sub-assembly embodiment over the previously described embodiments resides in the fact that the included product mold half is comprised of a relatively shallow conventional mold half **580a** that is secured to and carried by a relatively deep mold half support **580b**, and in the fact that sub-assembly crash pad elements **570** are formed integral with (i.e., comprise a part of) sub-assembly elongate gutter plate segments **590** and **594**. Each elongate gutter plate segment has a pair of tapered guide pins **572** which are each connected to and bi-directionally powered by a conventional bi-directional hydraulic or pneumatic actuator **576** that is attached to the underside of the gutter plate segment and that is situated in a recess **578** provided in the adjacent product mold half **580**. Each such guide pin co-operates with a tapered guide pin receptacle or receiver **574** provided in the product mold half **581**of the cap blow-mold sub-assembly that co-operates with sub-assembly **522**. See Figure 37. As in the case of other gutter plate segment embodiments, gutter plate segments **590** and **594** each include multiple spaced-apart and gutter flash-penetrating convex cleat insert element **593** and a multiple spaced-apart blind-hole excess gutter flash material receiver element **98**. As an alternative, the elongated excess gutter flash receiver elements **398** of the Figures 24 through 28 base blow-mold sub-assembly **322** may be substituted for gutter flash receiver elements **98**.

In Figures 38 through 42 I illustrate a further embodiment of the base blow-mold sub-

assembly of the present invention that my be advantageously utilized in the production of large, thick-walled thermoplastic resin blow-molded products. Such base blow-mold sub-assembly is referenced as **622** and includes product mold half **680** with a product cavity **682** having cavity mold parting-line perimeter **708**. Surrounding product cavity mold parting-line perimeter **708** are two, elongate gutter plate segments **690** and **692** which are end-abutted, which each have two transversely-movable pivot pins **726** and **728** and which each are supported on wear blocks **732** as shown in Figure 42. Each such elongate gutter plate segment also is provided with elongate excess gutter flash receiver elements **698** and with multiple cleat elements **693**.

Sub-assembly **622** differs from previously discussed base blow-mold sub-assemblies in several respects. First, sub-assembly **622** is provided with a gutter plate segment relief or undercut zone **770** which facilitates formation of an gutter flash integral take-out tab that may be used advantageously in connection with blow-molding machine operations that employ overhead take-away conveyors such as **46** of Figure 1. Second, the sub-assembly gutter plate drive is comprised differently than previously discussed gutter plate drives and is located beneath the sub-assembly base plate element **60**.

One such gutter plate drive embodiment is illustrated schematically in Figure 40, and a second embodiment is shown schematically in Figure **41**. The Figure 40 gutter plate segment drive embodiment is comprised of two, opposite but linearly aligned, double-slotted linear wedge cams **720** and **722** which are each guided linearly by a guide pillar **724** that co-operates with a respective one of wedge cam open-end guide slots **740** or **742**, and of two, bi-directional or extendible and retractable actuator devices **610** and **612** that are each connected in driving relation to a respective one of wedge cams **720** and722. The converging/diverging drive slots **744** and **746** in each wedge

cam engage a respective pivot pin **726** or **728**. In the Figure 40 illustration, bi-directional actuator **610** is shown in a retracted condition, and bi-directional actuator **612** is shown in an extended condition. Progressive separation of the integrally attached gutter flash surrounding the blow-molded product is accomplished by the sequential extension of extendible and retractable actuators **610** and **612** whereas in other discussed apparatus embodiments, such as that of Figure 5 and 6, the gutter flash separation is accomplished by actuator device retraction.

In the sub-assembly gutter plate segment drive version of Figure **41**, a single pivoted bi-directional or extendible and retractable actuator **610** is advantageously utilized rather than two such devices. In the Figure 41 scheme, linearly bi-directional actuator **610** drives a double-slotted rotary cam **748** which rotates about axis **750**. The rotary cam drive slots **752** and **754** each co-operate with a drive pin **756** carried by connector rod **758**, and such slots are developed in a manner whereby rotation of rotary cam **748** causes sequential extension movement of co-operating wedge cams**720** and **722**. In the Figure 41 illustration, double-slotted wedge cam **722** is shown in its extended condition.

Also, in both versions of base blow-mold sub-assembly **622** the gutter plate drive bi-directional actuator devices or bi-directional actuator device and co-operating rotary cam device are basically located at and secured to the underside of the sub-assembly base plate element **60**. Four arcuate guide slots **760** are provided in base plate element **60** and function to guide co-operating pivot pins. See Figure 42. Also, shown in Figure 42 is elongate bronze-like wear plate element **732** which is carried by base plate element **60** to provide wear support for gutter plate segment **692**. Since each sub-assembly gutter plate segment is free to be translated relative to and in directions parallel to the longitudinal axes of pivot pins **726** and **728**, the position of the gutter plate segment

gutter flash clamping surface relative to the cap blow-mold sub-assembly gutter flash clamping surface may be adjusted to alter product perimeter wall thickness and shape characteristics wall by changing the thickness of wear plate **732** or by changing the thickness of any support shim element provided under that wear plate element. Lastly, the corner filler block **762** which supports transverse gutter flash separator blade **97** may in some applications be advantageously fabricated of a material having low thermal conductivity rather than of metal.

The invention apparatus for separating surrounding integrally-attached gutter flash from a hollow blow-molded product may also be adapted to separate interiorly-situated gutter flash core from the product while the product is retained in its mold cavity. Such is basically accomplished by forming a bellows void in the interiorly-situated gutter flash core using the blow-molding machine compressed air supply, and afterwards progressively collapsing the bellows void using the co-operating interior gutter plate segments provided in the apparatus base blow-mold sub-assembly. The process of collapsing the gutter flash core bellows void causes the interior gutter flash to be progressively separated from the product at its interior mold parting-line perimeter.

Figures 43 through 47 schematically disclose details of a blow-mold assembly that is may be operated to progressively separate an interior integrally attached gutter flash core from a blow-molded product while the product is retained in the blow-mold assembly. Such blow-mold assembly is comprised of base blow-mold sub-assembly **822** and cap blow-mold sub-assembly **826** (Figures 46 and 47). Base blow-mold sub-assembly **822** has essentially the same the product cavity, surrounding elongate and pivoted gutter plate segment, and gutter plate segment drive component construction as that described above in connection with base blow-mold sub-assembly **622** and, accordingly, is therefore identified in the drawings by the same reference numeral. However, sub-assembly **822**

additionally includes a core gutter plate sub-assembly **922** that is comprised essentially of triangular interior gutter plate segments **990** and **992**, gutter bellows block **932**, and an interior gutter plate segment drive. Each such generally triangular interior gutter plate segment **990** and **992** has two pivot pins, **926** and **928**. In the Figures 43 through 47 base blow-mold sub-assembly **822** scheme, each pivot pin **926** is free to be translated and guided laterally relative to its longitudinal axis during the apparatus core gutter flash separation operation; pivot pins **928** are relatively fixed and remain in their initial position during the gutter flash core separation operation. However, as in the case of base blow-mold sub-assembly **622**, all of the included interior gutter plate segment pivot pins may be provided and operated as translatable pivot pins. Also, interior gutter plate segments **990** and **992** essentially fill the interior open area of base blow-mold sub-assembly mold half **880** in their initial operating condition save for the elongated bellows gap that separates those components and that registers with the gutter flash core bellows void cavity **930** provided in included bellows block **932**. (See Figure 46).

The gutter plate segment drive provided in sub-assembly **822** to translatably drive pivot pins **926** and pivot their co-operating interior gutter plate segments **990** and **992** about pivot pins **928** is schematically illustrated in Figure 45. Such drive utilizes a single bi-directional (extendible and retractable) actuator device **810** which is coupled to a wedge cam element **934** that includes the integral drive slots **744** and **746** for causing pivotal movement of surrounding elongate gutter plate segments **690** and **692** and also added drive slots **936** and **938** for causing pivotal movement of interior gutter plate segment **990** and **992**. Integral drive slots **936** and **938** each co-operate with a pivot pin **926** that projects through a respective arcuate guide slot **940** provided in base plate element **60**.

Also, and referring to Figures 46 and 47, cap blow-mold sub-assembly **826** is distinguished from other herein-disclosed cap blow-mold sub-assemblies in that, like sub-assembly **822**, it too includes a gutter flash core bellows void cavity **931**, and that cavity registers with the like cavity **930** of base blow-mold sub-assembly **822**. Cavity **931** basically is situated between the cap blow-mold sub-assembly stepped gutter flash clamping surfaces **83** that extend away from the product mold parting-line perimeter that defines the edge of the desired product interior through-opening area. Further, sub-assembly **826** also includes a conventional air injector needle **86** that is extended into and later retracted from the interior of bellows void formed by cavities **930** and **931**, and that functions to force core gutter flash parison material into complete contact with the surfaces of the co-registered bellows void cavities.

From a method standpoint, and after blow-molding machine **10** drops a heated thermoplastic resin parison to a position between separated blow-mold sub-assemblies **822** and **826** and the blow-mold sub-assemblies are operationally closed, compressed air is injected into the parison interior in parison areas situated in the mold-half product cavity and in the gutter flash core bellows void cavity to expand the parison into contact with the interior surfaces of those cavities. Following product and bellows void formation, exterior gutter plate segments **690** and **692** and interior gutter plate segments **990** and **992** are each pivoted to progressively separate gutter flash from the product along the sub-assembly mold-half product cavity surrounding and interior parting line perimeters. Afterwards the cap and base blow-mold sub-assemblies are operationally opened, and the blow-molded product and the separated surrounding gutter flash and interior gutter flash core are ejected from the blow-mold assembly for subsequent processing.

Various changes may be made to the relative sizes, shapes, materials of construction, and

method or procedural steps specifically described above and detailed in connection with Figures 1 through 47 of the drawings without departing from the intent, meaning, or scope of the claims which follow.

I claim as my invention: